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ABSTRACT

An attempt was made to determine the increase in predictive efficiency attained by adding noncognitive to cognitive variables to predict clinical performance of medical school graduates in residency training. Fifty-six graduates, 45 males, and 11 females, in 33 reading programs representing various specialties, were evaluated by supervisory physicians. Cognitive measures included assessment of students' progress in mastering factual elements of the medical curriculum, undergraduate grade point averages, and total scores on parts II and III of the National Board of Medical Examiners (NBME). Noncognitive predictors, derived from Holland's Self Directed Search (SDS), assessed interest in and aptitude for realistic, investigative, artistic, social, enterprising, and conventional types of occupations. Other noncognitive predictors were provided by the scales for autonomy, complexity, and theoretical orientation of the Omnibus Personality Inventory (OPI), and by the scores physicians gave applicants after admission interviews. Performance predictors, composites of cognitive and noncognitive factors, consisted of ratings on characteristics such as attitude, peer relations, medical information, skills, maturity, and patient rapport. Results indicated that a combination of cognitive and noncognitive predictor variables was a better predictor of physicians' postgraduate clinical performance than any individual variable or any one specific class of variables. (MH)

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EFFICACY OF COGNITIVE AND NONCOGNITIVE MEASURES IN PREDICTING CLINICAL PERFORMANCE OF RESIDENTS

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ABSTRACT--There has been relatively little research on the relationship between the clinical performance of physicians and the criteria used by medical school admissions and promotions committees. The studies which have been done primarily relate clinical performance to cognitive criteria. They have usually found only negligible relationships. By considering both cognitive and noncognitive variables, several recent studies have improved the prediction of clinical performance in medical school. The present study attempts to determine the increase in predictive efficiency attained by adding noncognitive variables to cognitive variables in predicting clinical performance of residents. The results of this investigation indicate that a combination of cognitive and noncognitive predictor variables functions much better than any individual variable or even any specific class of variables in predicting the postgraduate clinical performance of physicians.

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committees. The studies which have been conducted primarily relate clinical performance to cognitive criteria such as grades and intellectual ability and have usually found only negligible relationships (1).

These meagre results might stem from the nature of the variables investigated. Clinical performance entails a combination of cognitive and noncognitive elements such as responsibility, interpersonal skills, and attitude (2). This suggests that both cognitive and noncognitive predictor variables need to be examined in investigations of the prediction of clinical performance.

By considering both cognitive and noncognitive variables, several recent studies have in fact improved the prediction of clinical performance in medical school (3, 4). Additionally, the one study which predicts postgraduate clinical performance with some success used a mix of cognitive and noncognitive variables (5). The present study is an attempt to determine systematically the increase in predictive efficiency attained by adding noncognitive variables to cognitive variables in an equation predicting the clinical performance of medical school graduates in residency training.

METHOD

Participants

The investigation was conducted at the University of Missouri-Kansas City (UMKC) School of Medicine. According to the Academic Plan of the School (6), students enter a six-year combined BA-MD degree program directly from high school. In their first two years students study the liberal arts curriculum 75 percent of the time and the medical curriculum 25 percent. In the last four years these proportions are reversed. For two years after its founding in 1971, the School admitted many students who had completed or nearly completed their baccalaureate degrees. Most of these students entered the program at Year Three.

The 86 physicians, who had graduated from the School prior to 1978 and who were currently serving residencies, were contacted by mail and asked to participate in an investigation of the clinical performance of the graduates. The cover letter explained that their participation was voluntary and that confidentiality would be maintained. They were requested to allow the investigators to obtain an evaluation of their clinical performance by the supervisors of their residency training programs. Sixty of the graduates agreed to participate.

Procedure

A Resident Evaluation Form (REF) was sent to the director of residency training of each of the graduates who had agreed to participate. The director was requested to ask the "supervisory physician you believe to be most familiar with the resident's performance to fill in the evaluation form."

Forms for 56 of the graduates were completed and returned to the investigators. Twenty-four individuals who entered UMKC directly from high school and 32 who entered the School at Year Two or above were rated. Forty-five of the graduates rated were male; eleven were female.

The number of graduates in each type of medical specialty was: 19 in internal medicine; ten in family practice; five in anesthesiology; four each in ophthalmology, pediatrics, and psychiatry; two each in obstetrics-gynecology, pathology, and surgery; and one each in radiology, orthopedic surgery, plastic surgery, and emergency medicine. Thirty-three separate residency programs were involved.

Graduates for whom REF's were completed were compared with the graduates who had not been evaluated with the REF. They were found to be similar on 18 of the 20 predictor variables used in this study. Graduates evaluated with the REF had higher instructor's clinical performance evaluations on the Year Six internal medicine rotation ($t=2.24$, $p=.028$) and in the elective most pertinent to their residency ($t=2.61$, $p=.011$).

Criterion

The REF was used to obtain clinical performance ratings of the graduates. It is a considerably modified version of a form devised by Woodward at McMaster University.

It contains 33 scales which measure the performance of a resident in these areas: professional responsibility (five scales), relations with colleagues (two scales), self-appraisal ability (three scales), clinical skills (eight scales), relations with patients (four scales), work in groups (two scales), critical thinking ability (three scales), independent learning ability (four scales), and problem solving (two scales). Each scale measures a specific attribute of clinical performance, with one end of the scale anchored to a positive statement of the attribute and the other end anchored to a negative statement. Thus, the ratings obtained are measures of the graduates' behavior and not a comparison of their performance with that of other residents. An example of a REF scale is presented in Figure 1.

Reliability for the REF, as assessed by coefficient alpha, is .98. Concurrent validity is indicated by the .57 correlation (p=.003) between scores on the REF and the National Board of Medical Examiners (NBME) Part III examination.

Values for the criterion (or dependent variable) in this investigation were obtained by summing the ratings on each of the completed REF scales and dividing by the number of completed scales. This resulted in a mean REF score.

Predictor Variables

Twenty selection and evaluation measures were divided into three categories: cognitive, noncognitive, and performance.

Cognitive variables were those which primarily tapped intellectual ability and knowledge. An intramural measure of a student's progress in mastering the factual elements of the medical curriculum was provided by the Quarterly Profile Examination (QPE) (7), a multiple-choice examination administered every three months throughout a student's matriculation. For purposes of this investigation, the QPE total score which the student achieved immediately prior to graduation was used as an indicator of the fund of medical knowledge a student possessed upon graduation from UMKC. A second cognitive measure was the undergraduate GPA attained by a student in the baccalaureate portion of the combined degree program or the undergraduate GPA of those students who entered the program with a baccalaureate degree.

Total scores on NBME Parts I and II provided extramural assessments of cognitive ability for this study. These are nationally-recognized, multiple-choice, comprehensive examinations used for physician accreditation in this country.

Six of the noncognitive predictors used in this study came from Holland's The Self Directed Search (SDS) (8). This guide to educational and vocational planning assessed the students' interest in and aptitude for these types of occupations: (R) realistic, (I) investigative, (A) artistic, (S) social, (E) enterprising, and (C) conventional. Other noncognitive predictors were provided by the scales for autonomy, complexity, and theoretical orientation of the Omnibus Personality Inventory (OPI) (9). These instruments were administered during student orientation prior to matriculation.

An additional noncognitive predictor was the total score which a physician interviewer gave an applicant as a result of an admission interview. The score was a composite of the interviewer's ratings of the applicant's perception of and motivation for medicine, interpersonal relations, personal

soundness and maturity, decision-making ability, independence, personal ethics, and social awareness.

Performance predictors, which recent research (10) now shows to be complex composites of both cognitive and noncognitive elements, were the evaluations of students in required and elective rotations. These consist of ratings (on a one to nine scale of progressive excellence) of students' attitudes, peer relations, reliability, medical information, concepts, skills, maturity, patient rapport, ingenuity, conscientiousness, and integrity. In this investigation, the points assigned for each of the eleven areas were summed to provide a composite score. Evaluations of clinical performance were obtained for each of the graduates on the following rotations and electives: internal medicine (Year Four), obstetrics-gynecology (Year Five), the elective most pertinent to the type of residency in which the graduate was enrolled (Year Five or Six), and internal medicine (Year Six). The Year Six internal medicine evaluation includes ratings by self and by a peer as well as by the instructor.

Analysis

Pearson product-moment correlations were computed to determine the relationship between REF scores and the individual predictor variables. To determine if a weighted combination of predictors could better predict graduates' ratings on the REF, a step-wise, multiple regression which selected the combination of variables producing the maximum R^2 improvement on each step was performed (11). Variables were considered in the analysis if they had values for at least 50 of the 56 subjects. The criterion for terminating the analysis was defined as the step at which R^2 corrected for shrinkage (12) ceased to increase. Multiple regressions were also performed on the three categories of predictor variables (cognitive, noncognitive, and performance) and on their combinations to determine the relative contribution of each to explained REF score variance.

RESULTS

The mean REF score of the 56 graduates was 5.93 with a standard deviation of .97. Scores ranged from two to seven. Table 1 presents the Pearson product-moment correlations between REF scores and predictor variables.

Of the two intramural measures of cognitive ability (QPE and GPA), only GPA was correlated (r=.34) with a graduate's clinical performance as assessed by the REF. The correlation between the GPA of graduates who had received their baccalaureate degrees before entering the program and the REF was .34 (p=.031). This was very similar to the correlation of .35 (p=.046) found between these two variables among the students who pursued their baccalaureate and medical degrees simultaneously.

Two extramural measures of cognitive ability during medical school were available: scores from the NBME Parts I and II examinations. REF scores were found to be related to NBME II performance (r=.39) but not to NBME I performance.

The rating from the physicians' admission interview, scale scores of Holland's SDS, and measures of autonomy, complexity, and theoretical orientation were all considered to be noncognitive variables. Individually, none of these were significantly related to REF scores.

Measures of performance on rotations and electives during medical school were considered to contain both cognitive and noncognitive components. The following were significantly related to clinical performance as a graduate: the Year Four internal medicine instructor's evaluation (r=.26); the instructor's evaluation of the elective most pertinent to the type of residency being served (r=.31), and the Year Six internal medicine evaluations by the instructor (r=.34), by a peer (r=.34), and by the self (r=.31). Evaluation of a Year Five obstetrics-gynecology rotation was not related to clinical

performance during residency.

Although several of the predictor variables were individually related to graduate clinical performance, even the strongest relationship, that between NBME II and REF scores, accounted for only 15 percent of REF score variance. To determine if simultaneous consideration of the predictors would increase predictive efficiency, a multiple regression of all predictor variables against REF scores was computed. This resulted in a seven variable weighted model with a corrected multiple R of .65 which accounted for 43 percent of REF score variance. As shown in Table 2, all three categories of predictor variables, cognitive, noncognitive and performance, were represented in the model.

Multiple regressions performed on the three categories of variables resulted in corrected R^2's of .17, .14, and .16 respectively. Entering both performance and cognitive variables in a multiple regression resulted in a maximum corrected R^2 of .19. Cognitive and noncognitive predictors produced a corrected R^2 of .37; and performance and noncognitive predictors produced a corrected R^2 of .36.

DISCUSSION

The results of this investigation indicate that a combination of cognitive and noncognitive predictor variables functions much better than any individual variable or even any specific class of variables in predicting the postgraduate clinical performance of physicians. One of the major findings resulting from the multiple regression analysis is that the SDS and OPI scale scores substantially enhanced the prediction of clinical performance. These noncognitive measures were selected on the pragmatic basis of availability. They had been administered to incoming students prior to their matriculation and were therefore approximately six years old at the time of the REF rating. This might partially account for their lack of relationship with REF scores individually. Even with this limitation, when they were entered into a multiple regression in conjunction with cognitive measures, the explained variance

of REF scores increased from 17 to 37 percent. This indicates that the noncognitive measures contributed information which is relatively independent of that contained in the cognitive measures, and which is important for understanding and predicting future clinical performance. In this respect, these findings fundamentally agree with those of several earlier investigations (3, 4, 5).

Inspection of the multiple R's achieved by regressions of categories of predictors and combinations of categories leads one to believe that there is a large common factor which comprises much of the variance of the cognitive and performance predictors. Although both categories undoubtedly contain unique factors, it seems to be the common factor which accounts for REF score variance. Therefore, the addition of performance variables to cognitive variables in the multiple regression increased the explained REF score variance by only two percent from a corrected R^2 of .17 to a corrected R^2 of .19. Indeed, the performance measures seem to behave as cognitive measures. That is, clinical performance evaluations of rotations and electives by instructors and peers can function as grades in academic courses. Partial support for this interpretation comes from previous UMKC research which found that clinical performance evaluations by instructors were significantly related with the cognitive measures of QPE, NBME II, and GPA (7).

On the other hand, self-evaluation of performance in a Year Six internal medicine rotation was the only performance measure which entered the overall prediction equation. Self-evaluations overlap with personality measures of self-concept. This Year Six self-evaluation was found to be correlated .44 ($p=.010$) with another measure of self-concept that was available for a portion ($N=34$) of the study sample. It is likely that a self-concept factor, essentially a noncognitive personality variable, is responsible for the inclusion of this measure in the overall prediction model.

The above conceptualization of the students' clinical

performance evaluations enables one to account for both the large factor they have in common with the cognitive variables and the inclusion of the self-evaluation in the overall regression equation.

CONCLUSIONS

These empirical findings lend support to a widespread subjective dissatisfaction with the tendency to subordinate personal attributes to cognitive measures in selection and evaluation of medical students (13). The point of diminishing returns may have been reached in regard to the use of cognitive criteria. Given the cognitive homogeneity of most medical school applicants, it no longer suffices to select those intellectually capable of completing their medical education. Almost all are capable. The prime objective of medical education should be to select and train those who will perform best as physicians. Consideration of noncognitive criteria appears to be essential in order to further this objective.

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Figure 1

Example of a Scale from the REF

works well with colleagues ____:____:____:____:____:____:____ doesn't work well with colleagues

TABLE 1

CORRELATION OF RESIDENT EVALUATION FORM SCORES
WITH PREDICTOR VARIABLES

Category Variable	r	N	p
Cognitive			
Grade Point Average	.34	55	.006
Quarterly Profile Examination	.15	52	.142
National Board of Medical Examiners I	.21	56	.061
National Board of Medical Examiners II	.39	56	.002
Noncognitive			
Interview	.19	55	.081
Self-Directed Search			
Realistic	.13	50	.356*
Investigative	.02	50	.905*
Artistic	.10	50	.486*
Social	.06	50	.656*
Enterprising	.05	50	.705*
Conventional	-.23	50	.108*
Omnibus Personality Inventory			
Autonomy	.24	53	.084*
Complexity	-.19	53	.173*
Theoretical Orientation	.13	53	.357*
Performance			
Internal Medicine Year 4 - Instructor	.26	48	.035
Obstetrics-Gynecology Year 5 - Instructor	.13	54	.170
Elective Year 5 or 6-Instructor	.31	55	.012
Internal Medicine Year 6 - Instructor	.34	56	.005
Internal Medicine Year 6 - Peer	.34	54	.006
Internal Medicine Year 6 - Self Evaluation	.31	54	.012

*2 tailed

TABLE 2

SUMMARY STATISTICS FOR THE MULTIPLE REGRESSION
OF ALL PREDICTOR VARIABLES ON REF SCORES

N=45

Variables in Equation	Corrected R^2	Corrected R^2 Change	Multiple R	Partial r	B	Beta
National Board of Medical Examiners II	.15		.41		.00496	.400
Omnibus Personality Inventory Complexity	.21	.06	.49	-.30	-.16148	-.505
Self-Directed Search Realistic	.25	.04	.55	.27	.11983	.471
Internal Medicine Year 6 Self Evaluation	.30	.05	.60	.29	.30004	.241
Omnibus Personality Inventory Theoretical Orientation	.34	.04	.65	.30	.10297	.316
Self-Directed Search Artistic	.38	.04	.68	.29	.07183	.276
Social	.43	.05	.72	.31	.08245	.256
Intercept					1.187	